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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,408,868**, on October 18, 2002, by **RYAN ENERGY TECHNOLOGIES INC.**, assignee of Michael T. Sutherland and David F. Sim, for "Mud Pulse Landing Assembly for Use in Directional Drilling".

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MUD PULSE LANDING ASSEMBLY FOR USE IN DIRECTIONAL DRILLING

FIELD OF THE INVENTION

This invention relates to a mud pulse landing assembly for use in drill strings, particularly directional oil well drilling systems.

BACKGROUND OF THE INVENTION

Communicating with the instrumented end of a drill string inside a well bore deep within the Earth presents unique challenges. The development of real time communications for use in well bores has revolutionized the drilling industry; this is especially evident in measurement-while-drilling (MWD) technologies. Various wireless communication methods have been developed for MWD operations including mud pulse telemetry as well as electromagnetic-based systems. In traditional mud pulse systems, an orifice works in concert with a reciprocating piston to vary the drilling mud pressure near the bottom end of the drill string, thereby forming pulses that transmit through the mud to the surface. Using this system, digitally encoded messages can be sent via mud pulses, said pulses being received and interpreted by telemetry devices located at the surface. In traditional designs, the orifice represents the bore terminus of the tool string since previous designs have the orifice permanently fixed in position. As a result, it has been previously impossible to pass tools beyond this point, without first removing the entire drill string, a costly and time consuming task.

There is therefore a significant need for an alternate mud pulse telemetry system that does not obstruct passage of sensing devices through the drill string. A means to remove the obstruction, and an object of the present invention, is to have a mud pulse orifice incorporated into the removable MWD tool. This eliminates the obstruction and the limitation of previous mud pulse telemetry systems. A removable system must have the ability to self align, should be self-seating and be removable in either the upward or downward direction from the normal operating position.

SUMMARY OF THE INVENTION

The mud pulse landing assembly, in accordance with an aspect of this invention, allows for the removal of the mud pulse orifice, thus creating an

unobstructed passageway for any device that may need to be passed through the drill string.

The mud pulse landing assembly comprises a mud pulse landing sub having a longitudinal bore, contained with the longitudinal bore is positioned a stationary latching subassembly within which a removable MWD subassembly can be releasably connected. The mud pulse orifice and MDW tool containing the piston actuator are housed within the removable MWD subassembly. The removable MWD subassembly can be detached from the stationary latching subassembly by either applying downward pressure to drive the removable MWD subassembly further down the drill string, or it may be detached by applying an upward force to pull the removable MWD subassembly up the drill string. Provided is a means for releasably connecting the removable MWD subassembly to the stationary latch subassembly, where the removable MWD subassembly is self seating and self aligning.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of the mud pulse landing assembly.

Figure 2 is a side elevation of the mud pulse landing assembly.

Figure 3 is an exploded perspective view of the mud pulse landing assembly.

Figure 4 is an exploded view of the compact muleshoe (shown in side elevation view) and the anti-rotation latch receiver and thru-bore latch receiver (shown in sectional view).

Figure 5A, 5B and 5C are sectional views showing the insertion of the removable MWD subassembly into the stationary latching subassembly of the mud pulse landing assembly.

Figure 6 is a sectional view of the stationary latching subassembly with the removable MWD subassembly in operational position; also shown is the mud pulse orifice and piston.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a mud pulse landing assembly (10) for use in drill strings, particularly directional oil well drilling strings. The mud pulse landing assembly (10) comprises a mud pulse landing sub (11), a longitudinal bore (12), a stationary latching subassembly (14) and a removable MWD

subassembly (16). The invention provides a mud pulse landing assembly (10) that allows for removal of the internal components in either direction thus providing clear unobstructed passage of any device that may be required to pass through the drill string. The assembly (10) further comprises two ends, a first end (18) being adapted to connect to a first drill string component, and a second end (20) being adapted to connect to a second drill string component. The mud pulse landing assembly (10) is circular in cross-section.

Shown in Figure 2 is a cross-sectional view of the mud pulse landing assembly (10). The longitudinal bore (12) consists of a first region (22) and a second region (24), each being immediately adjacent to each other and concentric with reference to the longitudinal axis (26) of the assembly. The first region (22), with reference to the second region (24) is of a smaller diameter, thereby defining shoulder (28). The first region (22) of the longitudinal bore (12) remains clear and unobstructed in the assembled mud pulse landing assembly (10). In the second region (24), immediately adjacent to the shoulder (28) is a compact flow diverter (30) positioned so that the inside tapered diameter (shown in dot) of the compact flow diverter (30) tapers inwards in a direction facing the second end (20). Immediately adjacent the compact flow diverter (30) moving in a direction towards the second end (20) is a bumper ring (32), an anti-rotation latch receiver (34), a latch spacer (36), a thru-bore latch receiver (38), a second bumper ring (40) and a second compact flow diverter (42), positioned so that the inside tapered diameter (shown in dot) tapers outwards towards the second end (20). To retain the above elements in place within the second region (24) of the longitudinal bore (12), a retaining ring (44) is positioned immediately adjacent the second compact flow diverter (42), the retaining ring (44) being positioned within a circumferential box-shaped groove (46) located on the inside surface of the mud pulse landing subassembly (11). To maintain the anti-rotation latch receiver (34) in radial alignment, a key slider (48) is positioned within a recess (50) in the anti-rotation latch receiver (34), the key slider (48) being fixed in place by a first bolt (52) and a second bolt (54) that threadably engages the key slider (48). The first and second bolts (52, 54) are accessible from the exterior of the mud pulse landing assembly (10) by means of a first hole (56), through which the first bolt (52) passes, and a second hole

(58), through the second bolt (54) passes. The recess (50) of the anti-rotation latch receiver (34) is longer than the key slider (48) to accommodate vibrational movement in a direction parallel to the longitudinal axis (26). Although the ability to accommodate certain vibrational movement and stress is configured into the means by which the key slider (48) and anti-rotation latch receiver (34) engage, the first and second bumper rings (32, 40) further serve to reduce the various stresses that are commonly associated with directional drilling applications.

Shown in Fig. 3 is an exploded view of the stationary latching subassembly and removable MWD subassembly of the mud pulse landing assembly (10). As was explained above, the stationary latching subassembly comprises the compact flow diverter (30), the bumper ring (32), the anti-rotation latch receiver (34), the latch spacer (36), the thru-bore latch receiver (38), the second bumper ring (40), the second compact flow diverter (42) and the retaining ring (46). The removable MWD subassembly comprises a compact muleshoe body (60), first, second and third muleshoe legs (62, 64; third leg not shown) and an MWD tool (66). The muleshoe legs are attached to the MWD tool (66) by bolts or screws (68) or alternate suitable means. Each muleshoe leg, on the end mating with the MWD tool (66), has an elevated step (70) that is received by a corresponding receptacle (72) on the MWD tool (66). Similarly, with respect to each muleshoe leg, on the end mating with the compact muleshoe body (60), each muleshoe leg has an angled step (74) that corresponds to a receiving receptacle (76) on the compact muleshoe body (60). The interaction of the steps on each muleshoe leg with the corresponding receptacles on the receiving structures ensures there is no movement of the compact muleshoe body (60) with reference to the MWD tool (66).

In an assembled mud pulse landing assembly (10), the MWD subassembly is maintained in a fixed position with respect to the stationary latching assembly by means of anti-rotation latch receiver fingers (78) and thru bore latch fingers (80), where the anti-rotation latch receiver fingers (78) and the thru-bore latch fingers (80) are adapted to engage the compact muleshoe body (60). In the assembled position, the anti-rotation latch receiver fingers (78) and the thru bore latch fingers (80) interdigitate within the

region (81) defined by the latch spacer (36). Located on one end of the latch spacer (36) are a first set of tongue extensions (83) that fit within corresponding channels (85) on the anti-rotation latch receiver (34). Similarly, on the other end of the latch spacer (36) are a second set of tongue extensions (87) that fit within corresponding channels (89) on the thru-bore latch receiver (38). In the assembled position, the anti-rotation latch receiver (34) and the thru-bore latch receiver (38) remain spatially fixed due to the engagement between the tongue extensions (83, 87) of the latch spacer (36) and the corresponding channels (85, 89) on the anti-rotation latch receiver (34) and the thru-bore latch receiver (38). Since the anti-rotation latch receiver (34) is maintained in a fixed position by means of the key slider (48; see Figure 2), it follows that by means of the latch spacer (36), the thru-bore latch receiver (38) is also maintained in a fixed position. With respect to the fingers engaging the compact muleshoe body (60), as shown in Figure 4, the anti-rotation latch receiver fingers (78) have located on the inside surface of the terminal ends a plurality of elongated engagement splines (82) that engage the compact muleshoe body (60) at receiving elongated radial splines (84) located on the outside surface of the compact muleshoe body (60). Similarly, the thru-bore latch fingers (80) have located on the inside surface of the terminal ends a ridge (86) that engages a receiving groove (88) located on the outside surface of the compact muleshoe body (60). The need to maintain the various elements in a fixed position resides in the fact that in some applications, the internal electronics of the MWD tool require positioning at precise, accurate, known angles. By maintaining a fixed internal arrangement, the required angle of the MWD tool can be accurately set. Furthermore, to allow for accurate guidance of the drill, the MWD tool must be fixed with respect to the bend in the drill motor.

The releasable self-seating connecting means of the MWD subassembly (16) will be explained by making reference to Figures 5A, 5B and 5C. With the stationary latching subassembly (14) mounted within the mud pulse landing sub (11), the removable MWD subassembly (16) can be inserted into place. Shown in Figure 5A is the insertion of the MWD subassembly (16) into the mud pulse landing sub (11) from the second end (20). To facilitate insertion of the MWD subassembly (16) into the mud pulse

landing sub (11), the leading end (90) of the MWD subassembly (16) has been configured with a tapered edge (92). As the MWD subassembly (16) is moved through the longitudinal bore (12), the tapered edge (92) of the MWD subassembly encounters the elongated engagement splines (82) of the anti-rotation latch receiver fingers (78). To accommodate movement of the MWD subassembly (16) beyond the elongated engagement splines (82) of the anti-rotation latch receiver fingers (78) in a direction towards the first end (18; see Figure 2), the anti-rotation latch receiver fingers (78) have been adapted to flex outwardly thus permitting movement of the MWD subassembly (16) through the longitudinal bore (12). To accommodate this outward flex of the anti-rotation latch receiver fingers (78), the latch spacer (36) has a series of openings (91; see Figure 3) in positions corresponding to the terminal ends of each anti-rotation latch receiver finger (78). To further facilitate passage of the MWD subassembly (16) beyond the anti-rotation latch receiver fingers (78), the elongated engagement splines (82) are configured with a first angled side (94) and a second angled side (96; refer to Figure 4 to see angled sides) to allow for outward deflection of anti-rotation receiver fingers (78). As the MWD subassembly (16) is moved further through the longitudinal bore (12) towards the first end (18; see Figure 2), the tapered edge (92) of the MWD subassembly (16) encounters the ridge (86) on the inside surface of the terminal ends of the thru-bore latch fingers (80). To allow for passage of the MWD subassembly (16) beyond the ridge (86), the thru-hold latch fingers (80) are adapted to flex outwardly. To accommodate this outward flex of the thru-bore latch receiver fingers (80), the latch spacer (36) has a series of openings (93; see Figure 3) in positions corresponding to the terminal ends of each thru-bore latch receiver finger (80). To further facilitate movement of the MWD subassembly (16) beyond the ridge (86), the ridge is tapered at a first side (98) and a second side (100; refer to Figure 4 to see angled sides) to allow for outward deflection of the thru-bore latch receiver fingers (80), as shown in Figure 5B. As the MWD subassembly (16) is positioned into operational position, as shown in Figure 5C, the elongated splines (82) of the anti-rotation latch receiver fingers (78) engage the elongated radial splines (84) of the compact muleshoe body (60), thus preventing rotation about the longitudinal axis (Engagement not visible in Figure 5C). Concurrently, the ridge (86) on

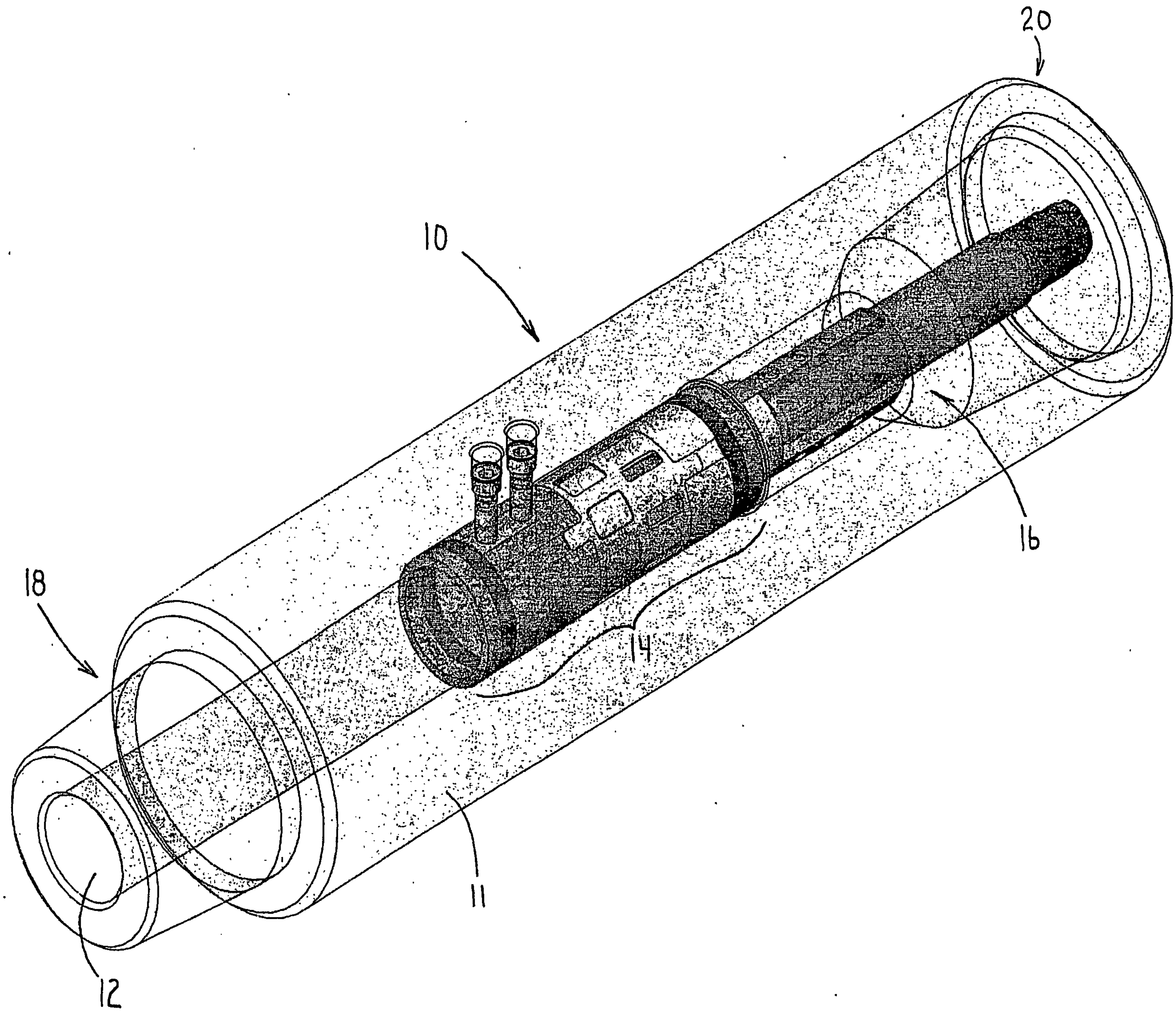
the thru-bore latch receiver fingers (80) position within the receiving groove (88) thereby locking the MWD subassembly (16) in place within the stationary latching subassembly (14).

The MWD subassembly can be removed from the stationary latching subassembly by either pushing it downwards or pulling it upwards through the drill string. Movement of the MWD subassembly in either direction is facilitated and self aligned by incorporating into the construction various tapers to eliminate the abutment of opposing shoulders. As previously mentioned, the elongated splines (82) of the anti-rotation latch receiver fingers (78) are dual tapered as are the ridges (86) of the thru-bore latch receiver fingers (80). To further facilitate movement in either direction, the compact muleshoe body (60) also incorporates various tapers. As shown in Figure 4, the receiving groove (88) of the compact muleshoe body (60) has a first outwardly tapering edge (95) and a second outwardly tapering edge (97). Similarly, in the region of the elongated radial splines (84) of the compact muleshoe body (60), there is a first outwardly tapering edge (99) and a second outwardly tapering edge (102). An additional taper (104) is incorporated into the design of the compact muleshoe body (60) to further facilitate movement, especially when directing the MWD subassembly upwards through the drill string.

In order for the mud pulse landing assembly to generate communicative mud pulses that can be measured at the surface (i.e. mud pulse telemetry), a system well known in the art for producing such pulses must be present which includes an orifice and a reciprocating piston. In traditional mud pulse telemetry, the orifice is a fixed element in the construction. In an effort to allow for passage of various devices through the drill string without obstruction by the orifice, the present invention allows for removal of the orifice due to its incorporation into the removable MWD subassembly. As shown in Figure 6, the compact muleshoe body (60) has a longitudinal bore (105) that contains a mud pulse orifice (106) that has one face positioned against a formed shoulder (108) on the inside surface of the compact muleshoe body (60). The mud pulse orifice (106) is retained in position by a suitable means, shown in the figure as a retaining ring (110). To produce a mud pulse, a piston actuator (112), housed within the MWD tool

is activated, bringing into close proximity to the mud pulse orifice (106) a piston (114) that results in higher mud pressure. The activation of the piston is controlled by various means well known in the art.

Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention, as described herein.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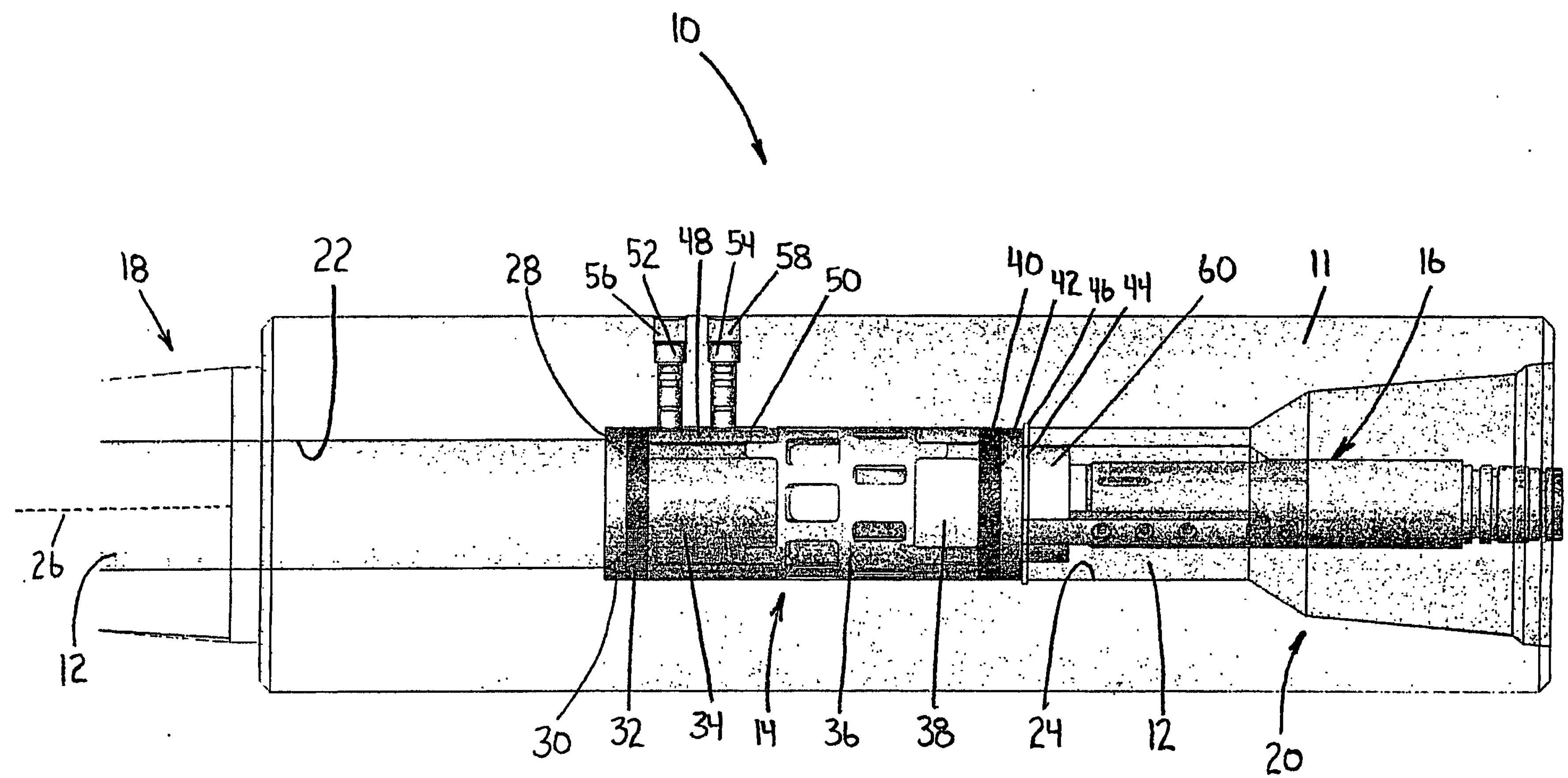
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FIG 2

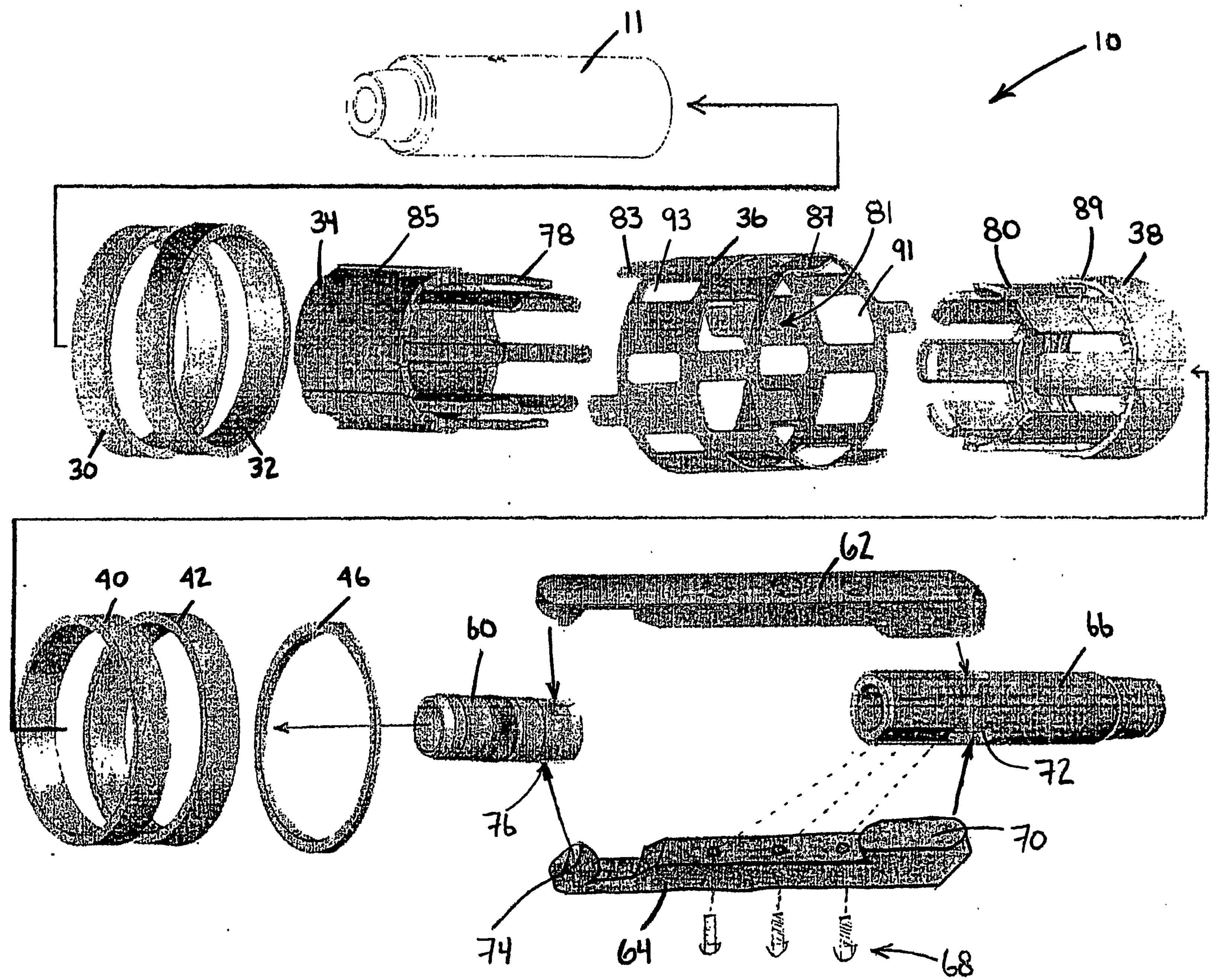

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Fig 2

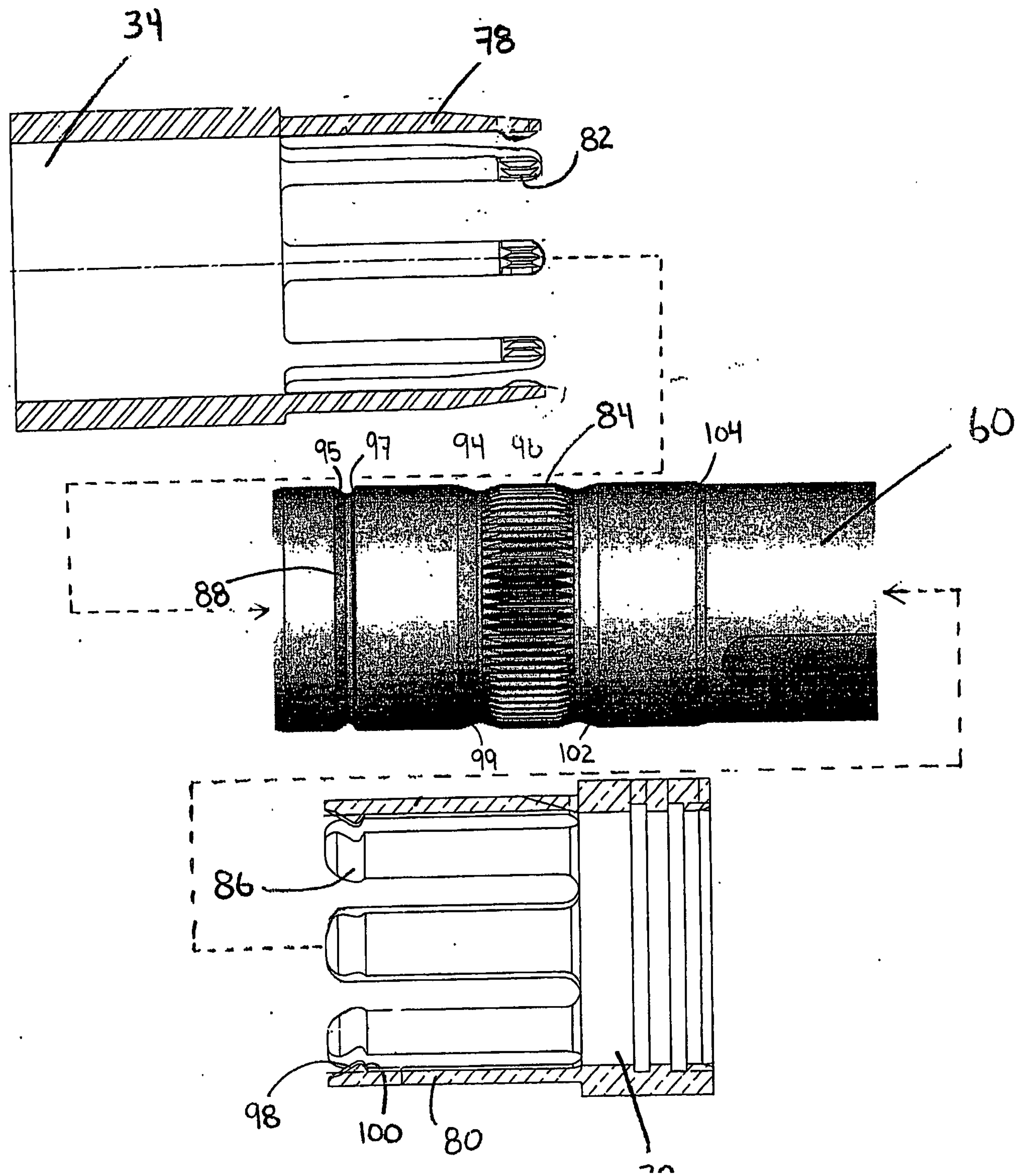


FIG 4

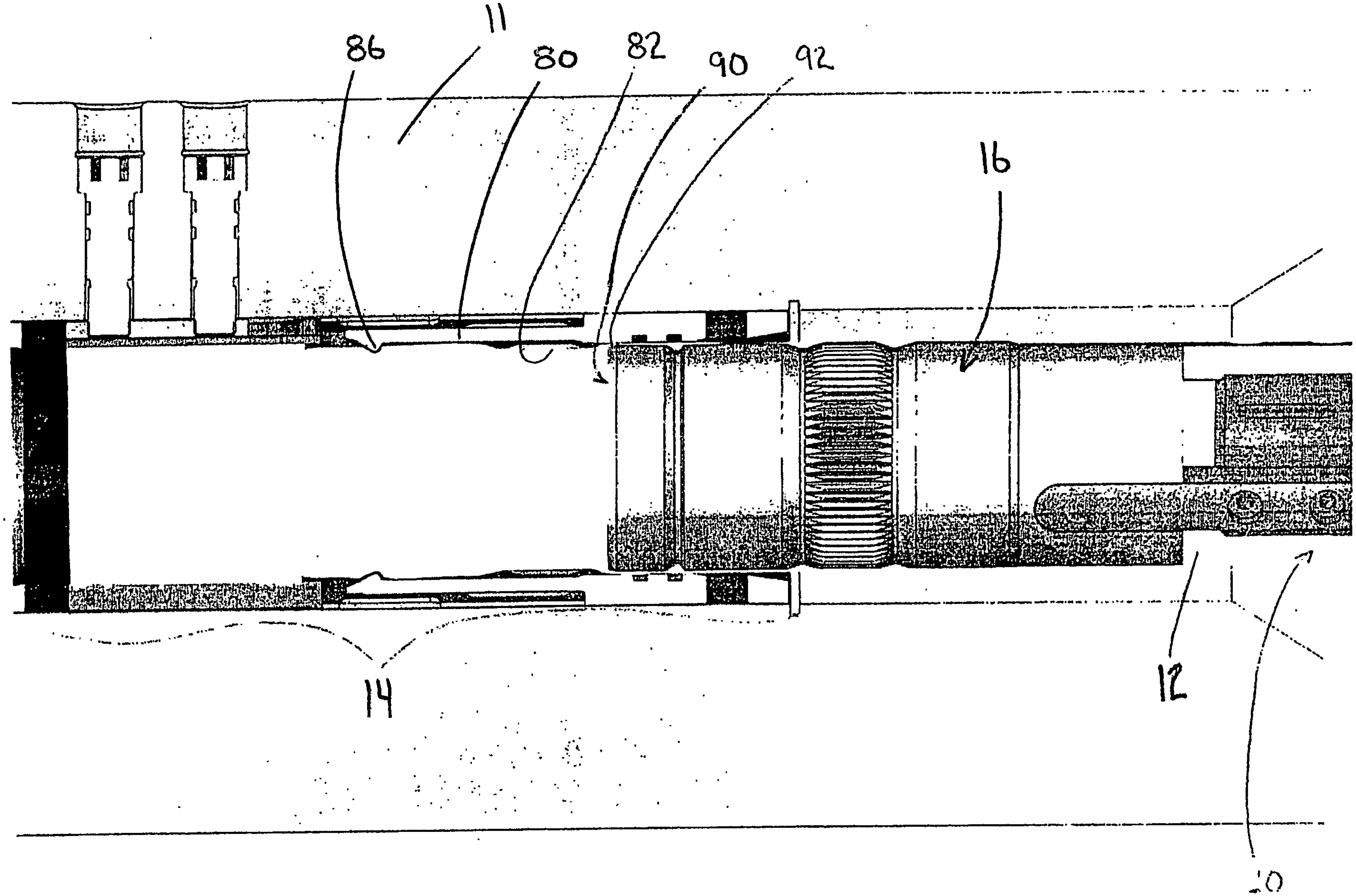


Fig 5A

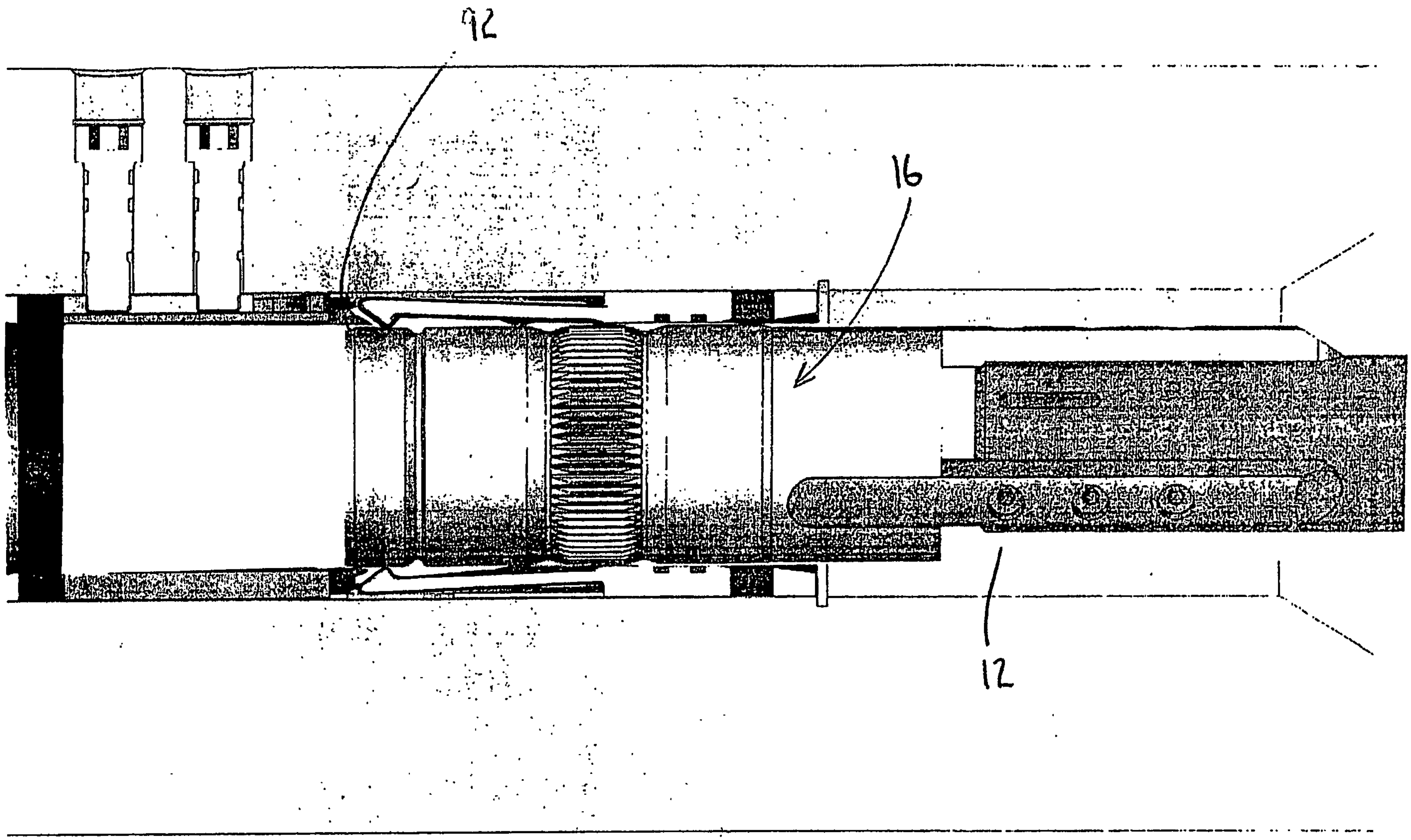
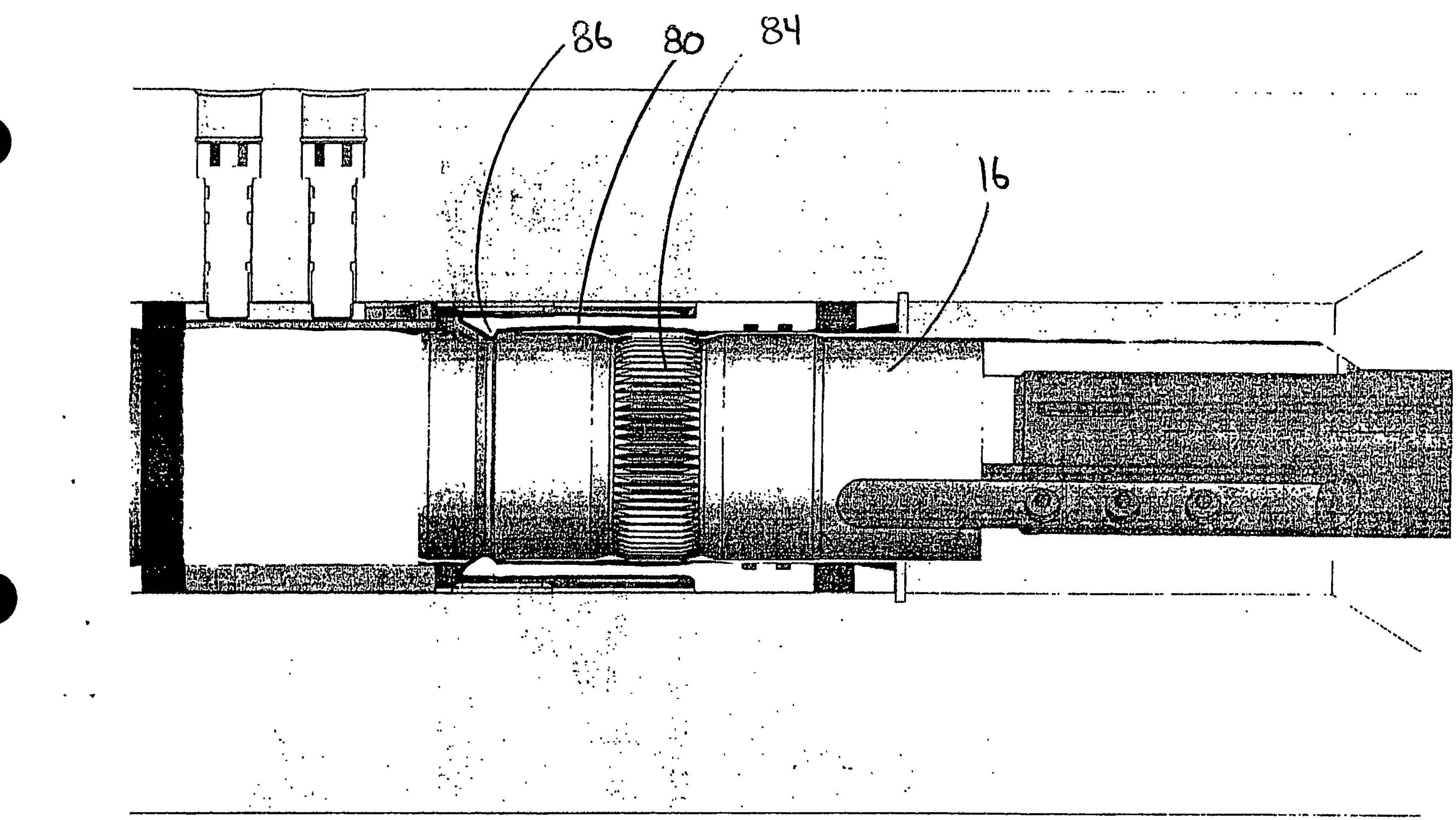


FIG 5B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16

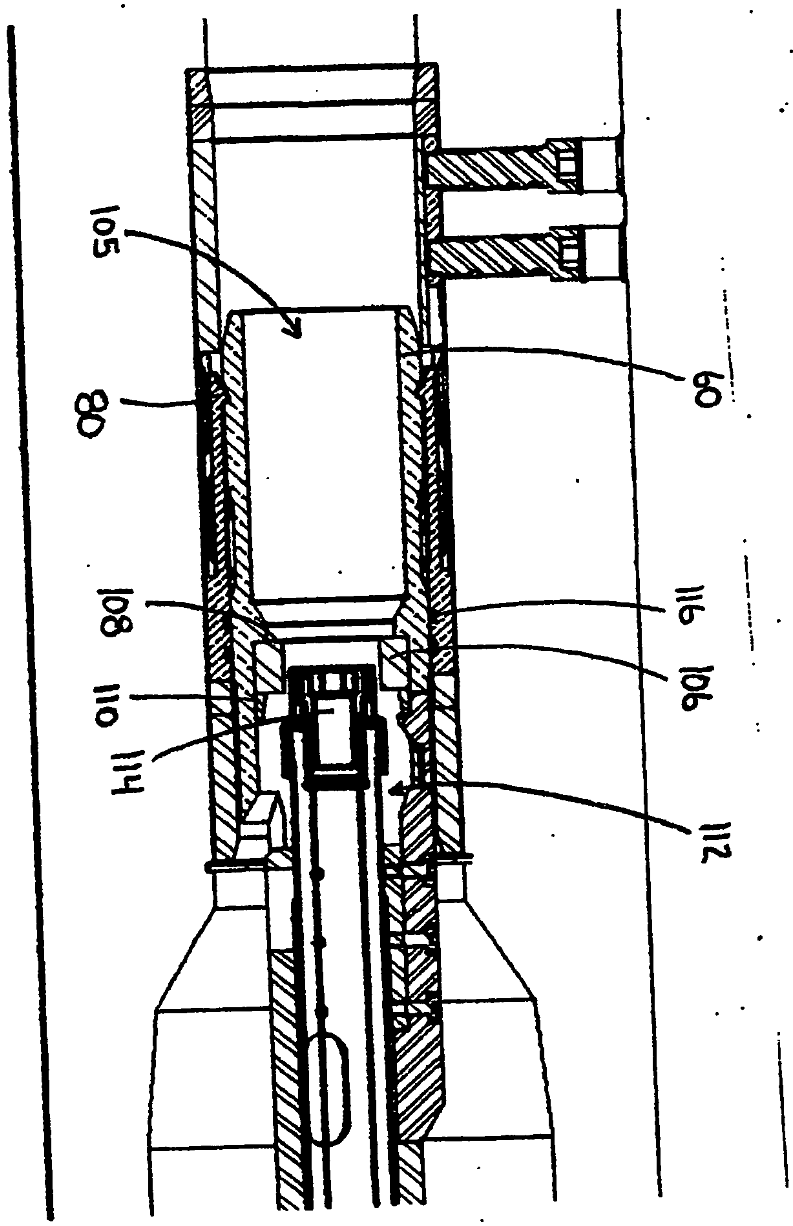

FIG. 6